Self-healing high voltage electrical insulation materials

Cédric **LESAINT** (1), Øystein **HESTAD** (1), Sverre **HVIDSTEN** (1), Wilhelm R. **GLOMM** (2)

1 Sintef Energy Research, Trondheim, Norway, cedric.lesaint@sintef.no, Oystein.hestad@sintef.no, sverre.hvidsten@sintef.no.

2 SINTEF Materials & Chemistry, Trondheim, Norway, Wilhelm.glomm@sintef.no

Electrical treeing can be the precursor to catastrophic failure for electrical insulation materials and hence significantly shorten their service lifetime. Considering that damage inside the composites (thermoset insulation materials containing fillers) is difficult to detect and particularly to repair, the ability to self-heal is very attractive, especially in challenging environments. The main purpose of this paper is to present results from electrical testing of a self-healing composite. Such a composite could e.g. be used as the solid electrical insulation in subsea power cable connectors for deep water oil exploitation where repair is very time consuming and costly.

The approach presented in this paper for development of self-healing thermoset electrical insulation materials is based on a technology developed by White et al. in 2001, intended to halt mechanical degradation of the material: Microcapsules filled with a monomer (healing agent) are added to the insulation materials (epoxy) prior to casting. When cracks propagate in the material the microcapsules will rapture, releasing liquid healing agent into the crack. The final step of the self-healing process is the polymerization of the monomer, which occurs upon contact with a catalyst added to the epoxy resin.

Electrical degradation by electrical treeing has many similarities with mechanical cracking of the material. For a system containing microcapsules, one or more of the branches of the electrical tree will likely break a capsule, thus filling the electrical tree with the liquid monomer. As the tree structure is interconnected, most of the tree structure is likely to be filled. This depends on the partial pressure and viscosity of the monomer and the surface tension of the hollow tubes. The filling itself should extinguish critical discharges, making further growth less likely. Upon polymerization, further development of the electrical tree should halt, or at least be significantly delayed. A series of tests was conducted to study electrical degradation and breakdown of the thermoset insulation with and without microcapsules with monomer (healing agent) including electrical treeing from a metal needle cast in epoxy, electrical treeing from a micro void in epoxy and electrical breakdown voltage testing of the insulation material using Rogowski test objects. The experiments where a needle or a void is used as an initiation site for electrical treeing provide the possibility of studying the inception and propagation of the phenomena using a microscope. This setup was used to study the interaction between the electrical tree and the micro-capsules in situ, and showed the direct attraction of the electrical trees towards the microcapsules.